

In-Situ Fringe Pattern Profilometry for Feed-Forward Process Control, Phase I

Completed Technology Project (2018 - 2019)



Project Introduction

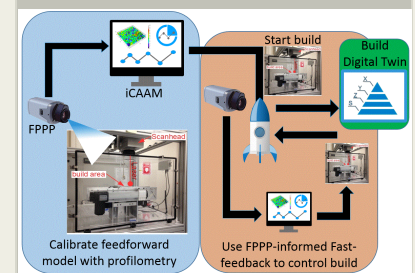
This project aims to implement novel techniques for feedforward and feedback control that will allow better control, validation, and documentation of Selective Laser Melting (SLM) additive manufacturing (AM). Three complimentary key innovations will be realized in this project (two in Phase I and a third in Phase II) by combining and improving two current technologies. The first is the integration of Fringe Pattern Projection Profilometry (FPPP) into the SLM process. FPPP is the first profilometry technique that can capture high resolution dimensional measurements of the entire SLM build platform, *in situ* and nearly instantaneously. This facilitates direct dimensional measurement and validation of every single layer, and post-process 3D models (built from the measurements) for the digital twin. By capturing all dimensional information (including residual stress induced distortion) the FPPP sensor will provide a unique set of data for calibration of AM modelling software, which is the second key innovation.

The FPPP data will identify defects in layer morphologies that can be used to train unique integrated computational adaptive additive manufacturing (iCAAM) *feedforward* modeling tools (distortion is predicted and compensated for with the build strategy before the build starts). In most simulators, the layer thickness is assumed to be constant and perfect, but it is not. FPPP data will quantify the true variability present in layer thickness as the part is built. Access to this information will allow more accurate calibration of the model so final part distortion can be virtually eliminated. In Phase II the model will also be inverted and turned into a fast-feedback lookup table for further tuning the build process to compensate for suboptimal layer morphologies that may arise, which is the third key innovation. The result will be a combination of hardware and software tools that eliminate distortion and capture critical information for the digital twin.

Anticipated Benefits

The technology is applicable to the Space Launch System (SLS), which is currently building components for the RS-25 rocket engine. Feedforward control can also avoid waste of time and cost associated with failed builds for several other rocket nozzles currently built with NASA SLM systems. Other applications include CubeSats and small deep space engine components that need to be distortion free.

DoD need improved SLM for flight critical aerospace components. The medical device industry needs better validation for SLM processes in order to pass FDA scrutiny before parts can be used commercially. The feedforward technology could be readily implemented by any commercial SLM supplier that builds critical components which require validation.



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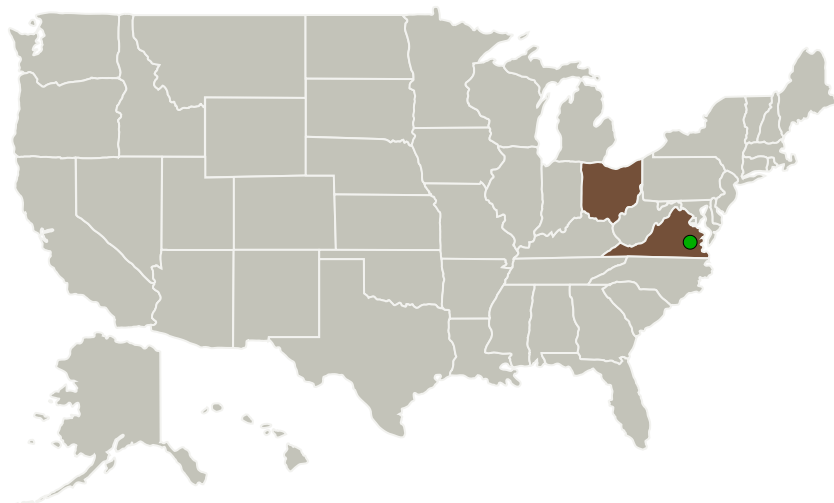
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Primary U.S. Work Locations and Key Partners




| Organizations Performing Work | Role | Type | Location |
|----------------------------------|-------------------------|-------------|-------------------|
| Universal Technology Corporation | Lead Organization | Industry | Dayton, Ohio |
| ● Langley Research Center(LaRC) | Supporting Organization | NASA Center | Hampton, Virginia |

Primary U.S. Work Locations

| | |
|------|----------|
| Ohio | Virginia |
|------|----------|

Project Transitions

 **July 2018:** Project Start

 **February 2019:** Closed out

Closeout Documentation:

- Final Summary Chart(<https://techport.nasa.gov/file/141114>)

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Universal Technology Corporation

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

Carlos Torrez

Principal Investigator:

John Middendorf

Co-Investigator:

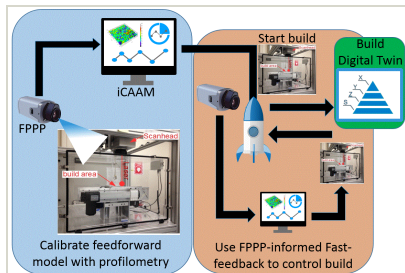
John Middendorf

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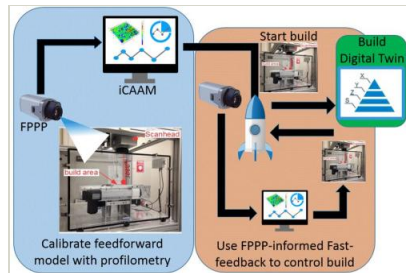
Images



Briefing Chart Image

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(<https://techport.nasa.gov/image/126975>)



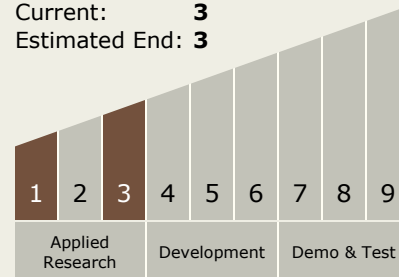
Final Summary Chart Image

In-Situ Fringe Pattern Profilometry for Feed-Forward Process Control, Phase I

(<https://techport.nasa.gov/image/126263>)

Technology Maturity (TRL)

Start: **1**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
 - TX12.4 Manufacturing
 - TX12.4.2 Intelligent Integrated Manufacturing

Target Destinations

Earth, The Moon, Others Inside the Solar System